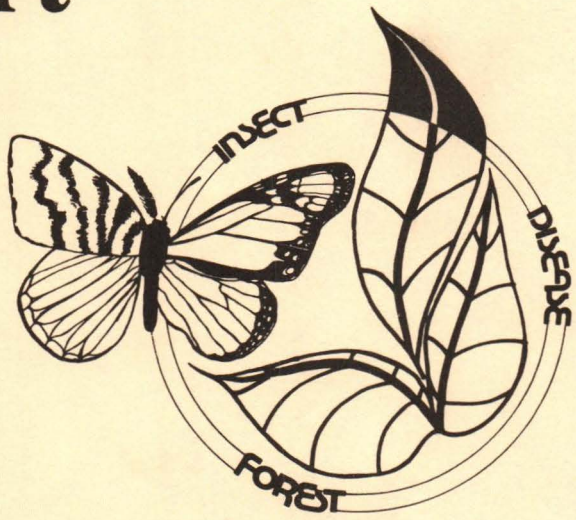
Missouri Forest Pest Report 1988



Missouri Department of CONSERVATION

Forestry Division

Missouri Forest Pest Report

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Introduction

The winter season of 1987–1988 was one of near average precipitation and temperature. Winter injury on conifers and cedars was generally minimal in most areas of the state. A severe ice storm, however, caused extensive damage to both hardwoods and conifers in the southwestern and south central part of the state.

Spring weather started and ended dry. Seedling mortality was extremely high on stock planted in both 1987 and 1988 because of low soil moisture levels. Frost damage also defoliated a wide range of hardwood species in April. Most of the damage was evident in low lying pockets in the Ozark Region.

The drought of the 1988 season is not new news to anyone. In Missouri, the drought was not as "extreme" as in other states. Drought conditions were severe north of the Missouri river, mild to moderate south of the river, and conditions were near normal to moist in the Bootheel Region.

Tree mortality in 1988 as a direct result of the drought was generally minimal. The impact of the drought on tree health, however, will be evident for a number of years. Decline problems and attack by secondary insects and pathogens will increase because of the weakened condition of drought stressed trees. As a result, we expect an increase in some problems such as pine wilt disease of Scotch pine, oak decline in the Ozarks, and some canker and borer pests.

Outbreaks, expansion of known ranges, and new pest occurrences for Missouri were evident for a number of pests in 1988. Ash yellows of white ash, western gall rust of Scotch pine, gypsy moth, spider mites and eastern tent caterpillar will be highlighted as important pest problems in this report.

Department Foresters were very busy servicing forest and shade tree pest inquiries this year. Requests for assistance with pest problems has escalated in the past few years, particularly in urban areas. This year's drought also contributed significantly to urban tree problems and requests for help.

As evident from the dimension of the paper, we have made changes in the size, and organization of the report this year. The report is still an annual summary of the important, as well as incidental pest problems, that occurred in Missouri in 1988.

Conditions in Brief

Forest Insects

European Pine Sawfly—occurred in moderate to heavy numbers on Scotch and mugo pines this spring in scattered locations in north, east-central and west-central Missouri.

Fall Webworm—occurred in light to moderate size populations on walnut trees and other hardwood species in southwest Missouri in 1988.

Gypsy Moth—during summer 1988, 11 male moths were trapped in the state. The Department of Agriculture found five male moths in the St. Louis area, four were found in Webster County near Seymour, one was trapped in Texas County at Highways W and 17, west of Summersville and one was trapped in the James A. Reed Wildlife Area, near Lee's Summit in Jackson County. A combined effort between the Department of Agriculture, USDA A.P.H.I.S. and other organizations resulted in the location and monitoring of 7,500 traps in 1988.

Redheaded Pine Sawfly—populations were low in 1988.

Spider Mites—occurrence was heavy over the state in 1988. The very dry hot summer was conducive to spider mite population development. Species affected were Scotch pine and spruce.

Forest Diseases

Ash Yellows—caused by mycoplasma-like organisms was confirmed for the first time in Missouri from four counties. The disease was found on white ash growing in natural stands that were exhibiting severe decline symptoms.

Actinopelte Leaf Spot—infection levels were generally low although some pin oaks became heavily infected late in the growing season.

Botryosphaeria Canker—of Rocky Mountain juniper was found in a single location in Jackson County.

Diplodia Tip Blight—new branch tip infections on Austrian pine were at low levels. Branch cankers, and dieback from previous years' tip infections caused decline on many older pines. Tip infections on Scotch pine in Christmas tree plantations were common around the state.

Drought Damage—the dry weather caused a large amount of seedling mortality. An increase in dieback and decline symptoms, mortality of large trees, and some insect and disease problems related to weakened hosts occurred because of the drought.

Dutch Elm Disease—a slight increase in this disease was observed. Many young elms in hedgerows were infected as well as large elms in urban areas.

Fire Blight—infection was heavy on a wide range of rosaeceae species.

Frost Damage—was evident on a variety of hardwood species in low lying areas, mainly in the Ozark Region.

Hypoxylon Canker—was common on drought stressed oaks in both urban and forest situations.

Lophodermium Needlecast—was at low levels in 1988, particularly in comparison to the outbreak of 1987.

Oak Decline—drought conditions increased oak decline in the eastern Ozark forests. Oaks in the red oak group, particularly scarlet oak, were the most seriously affected.

Oak Wilt—was common in 1988, although most damage occurred in urban areas on mature pin, red and black oaks.

Pine Wilt Disease—was spurred on by the drought and continued at epidemic levels around the state. Infected Scotch pine growing in Christmas tree plantations were found in significant numbers for the first time since 1980.

Sycamore Anthracnose—failure of sycamores to foliate in the spring occurred because of extensive canker and shoot blight. Drought conditions slowed refoliation and contributed to branch dieback on many anthracnose infected trees.

Western Gall Rust—was positively identified from a Boone County Christmas tree plantation. This is the first find of the disease on Scotch pine in Missouri.

The Program

In 1962, a cooperative program, the Forest Pest Control Program, was entered into with the U.S. Forest Service by the Forestry Division, Missouri Department of Conservation. Under the original agreement the effort is designed to detect, evaluate and control forest insects and diseases on state and private land. Department foresters and other personnel report occurrences of damaging insects and diseases. A forest entomologist and forest pathologist coordinate the program.

Insects, diseases, drought and other predisposing factors can cause damage to trees and shrubs which may go unnoticed until mortality occurs. Tree losses occur on an annual basis in the forest from hardwood borers and defoliators, pine cambial feeders, root rot, canker and stem diseases, drought and overmaturity.

Trees under stress were vulnerable to attack by insect borers, and a host of canker fungi and root rot fungi. Some factors which stress trees are drought, compacted soil, root disturbance, lightning strike, insufficient soil elements and wet or dry soil conditions to list just a few. Maintaining tree vigor is the most important consideration to ensuring a long life.

Projects

The cooperative team effort of Department foresters and Forestry Division staff specialists resulted in a well coordinated, successful Forest Pest Management Program in 1988. Over 3,500 forest and shade tree requests were serviced statewide in 1988. The services of staff specialists were available to foresters and others. In February and March, four Pest Management training sessions were held in St. Louis, Kansas City and St. Joseph for foresters and personnel associated with the green industry. In May, two pest sessions were held in Springfield and Poplar Bluff. These meetings are designed for foresters, arborists, and urban forest pest management specialists. Over 380 people attended these six meetings.

Department foresters and staff specialists serviced over 2,000 pest related telephone calls. Over 1,000 diagnoses of tree problems were made for the state. Forest pest management specialists and district foresters presented technical sessions to arborists at regional technical seminars and conferences. Gass and Luley conducted detection and evaluation surveys on major insect and disease problems in 1988 on 5,000,000 acres. Reports were prepared and submitted to the U.S. Forest Service.

Plant Clinics were conducted in the St. Louis, Kansas City and Jefferson City areas to service the public in assisting them with their tree and shrub questions. A total of six Forest Insect and Disease Status Reports (April through September) were prepared and sent to all Missouri Christmas Tree Producers, most Department personnel, and other individuals involved in tree care, totaling 1,200 copies per month. Gass and Luley attended the annual State Cooperators Meeting hosted by the U.S. Forest Service in St. Paul, Minnesota in March. Luley attended the 1988 American Phytopathogical Society Conference in San Diego, California in November.

We completed our seventh season with the Integrated Pest Management Program (IPM) with the University of Missouri-Columbia. This multi-state reporting program has been developed to collect and computerize pest occurrence data for most economic plant pests in the state. Forestry Division is reporting results to the IPM Program for incidence of insects and diseases on forest and ornamental trees.

Administrative Studies

Luley established a foliar disease control project on black walnut seedlings at the George O. White Forest Nursery. Nitrogen and the fungicides benlate and manzate were evaluated for control of anthracnose and Mycosphaerella leaf spot on 1–0 seedlings. The project will be followed up, in cooperation with the genetics program (T. Robison), to determine the effect of the foliar disease on growth parameters, and survival in the field. Luley also evaluated the pathogencity of *Fusarium solani* isolates from

black walnut cankers. Seedlings of black walnut were inoculated in the greenhouse with isolates of the fungus from Missouri and Kansas.

Luley and Gass surveyed Scotch pine plantations and windbreaks for pine wilt disease. The incidence of healthy, dead and pine wilt infected trees was determined.

A study was initiated, in cooperation with Frank Rycyk of the Department of Agriculture, to determine if a Scotch pine with a gall disease was infected with either eastern or western gall rust. Results of all the projects are reported in the appendix.

Two cooperative projects with the University of Missouri-Columbia have been funded by the Department. Dr. Marc Linit, Entomologist with the University, is the principal investigator for both studies. Dr. Linit is studying the transmission of the pinewood nematode to Scotch pine by the insect vector *Monochamus carolinensis*. The second study is focusing on black walnut nut loss as caused by the walnut curculio.

Forest and Shade Tree Insects

Hardwood Defoliators

Eastern Tent Caterpillar—populations were high over the south one-half of the state in spring on wild black cherry shrubs and trees. Webbing intensity varied from one to 10 webs per tree.

Trend—populations should be moderate to heavy in 1989.

Suppression—no control was carried out in 1988.

Fall Webworm—populations were light to moderate in southwest Missouri and light in north central, south central and southeast. Webbing of black walnut, pecan, hickory, persimmon and redbud was common.

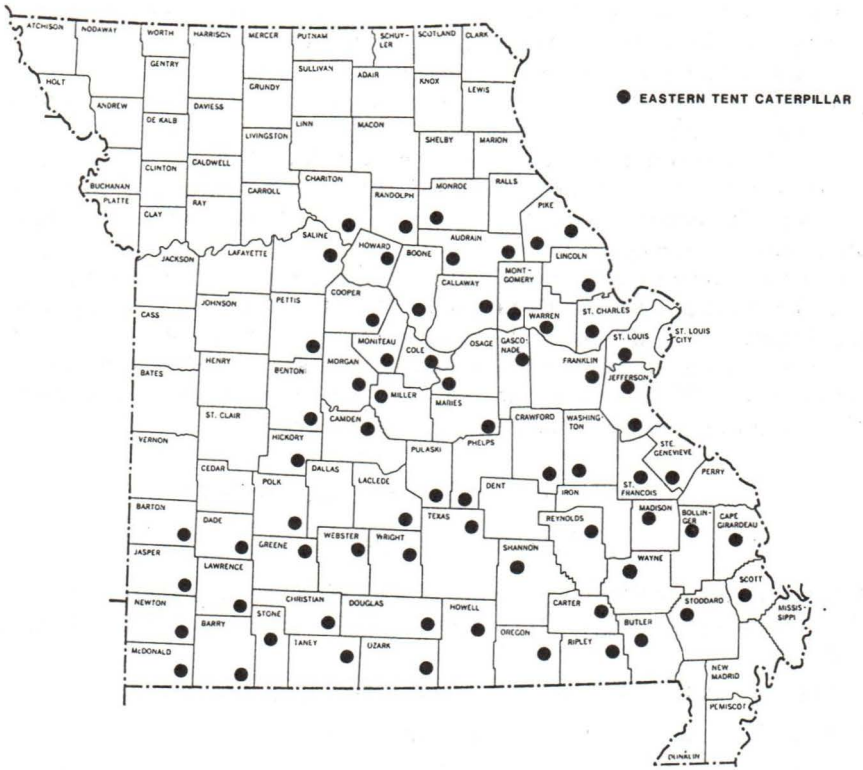
Trend—populations should be light to moderate in 1989.

Suppression—various walnut and pecan growers sprayed their trees to control this insect.

Gall Insects—numerous reports were received statewide regarding heavy gall infestations in 1988. Gall insects such as flies, wasps, psyllid gall insects and mites are active in spring. These insects lay their eggs in succulent leaf or twig tissue where the swollen parts eventually develop. Galls commonly observed are on hackberry, hickory, pin oak, bur oak, hard maple and silver maple. Elm and walnut leaves also have galls in early summer. Woody stem galls are common on pin and shingle oak.

Trend—insect gall infestation is a part of nature. We will always have gall insect formation with cyclical fluctuations. Galls will always be difficult to control.

Suppression—no control was conducted for gall insects in 1988.



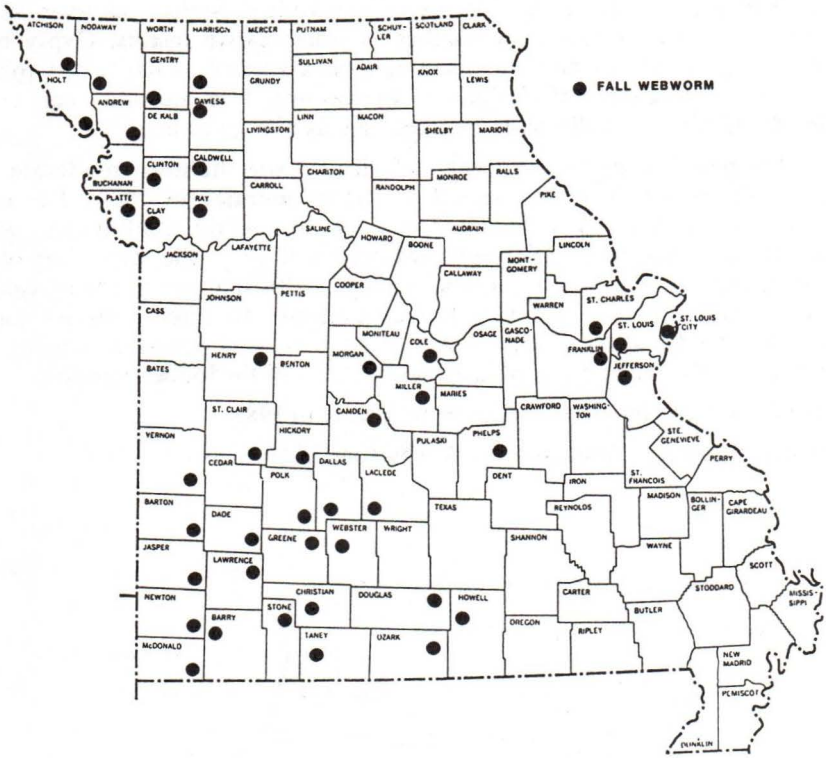
True Tree Grasshopper—caused light defoliation in Reynolds and Wayne counties. Its preferred hosts are white oak, red oak, hickory and flowering dogwood. Feeding produces a lacy appearance to the foliage. It is an insect of the forest and no control was necessary.

Trend—populations in 1989 should be larger causing moderate to heavy defoliation.

Walnut Caterpillar—populations were light to moderate over the state on black walnut, pecan and hickory. Leaf feeding begins in July and ends in September. Other *Datana* species feed on red oak, post oak, huckleberry and sumac.

Trend—populations in 1989 will be light to moderate in most areas of the state.

Suppression—a number of nut growers sprayed their trees for this insect with an approved insecticide.



Gypsy Moth—during the summer of 1988, the gypsy moth defoliated millions of acres of forest land in the northeastern United States. Spot infestations still remain in several states while the infested range continues to grow in central Michigan.

Personnel of the Missouri Department of Agriculture trapped five male moths in St. Louis, four in Webster County near Seymour, one in Texas County at Highway W and 17 and one in the James A. Reed Area near Lee's Summit. To date, no spot infestations have been discovered in Missouri.

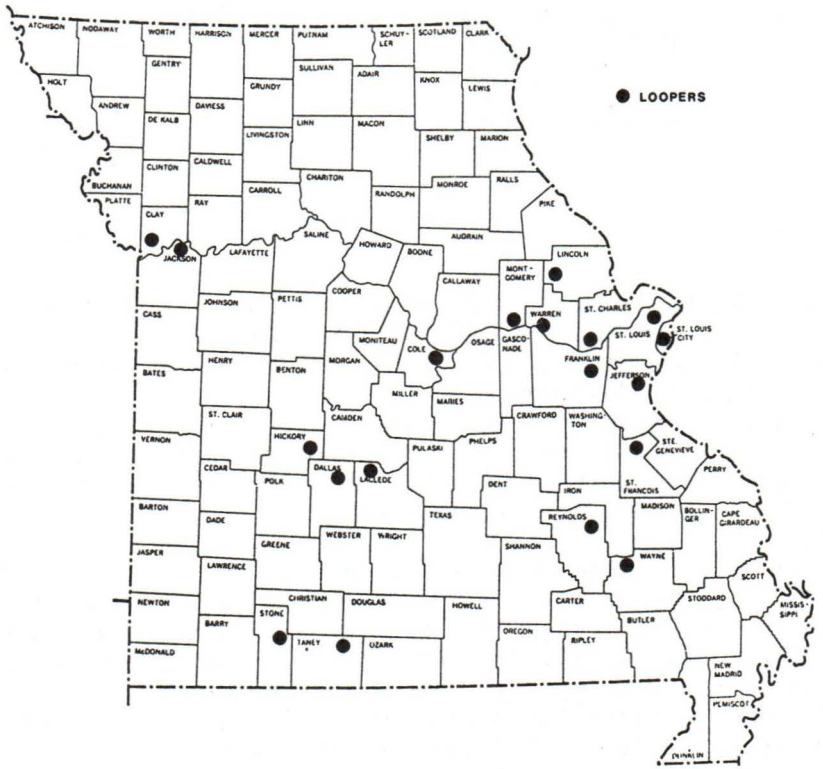
In 1988, 7,500 gypsy moth traps provided by U.S.D.A., A.P.H.I.S, P.P.Q, were located and monitored by personnel of the Missouri Department of Agriculture, Plant Industry Division and in cooperation with the U.S.D.A., Animal Plant Health Inspection Service. Other cooperating agencies were the Department of Natural Resources, State Parks and Historic Preservation, National Campers and Hikers Association, Corp. of Engineers and John Grinstead at Ft. Leonard Wood.

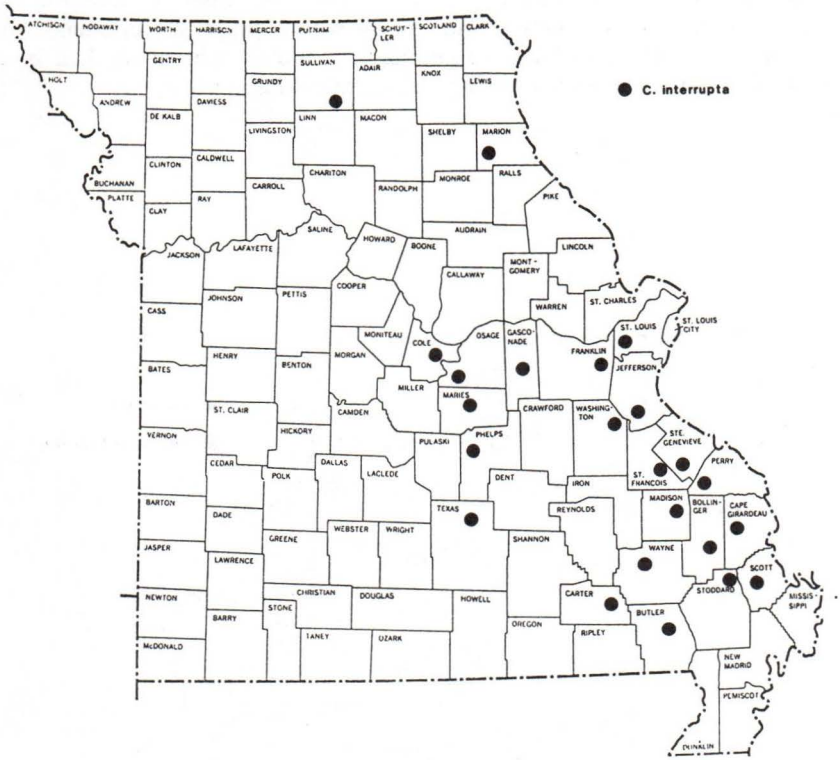
The gypsy moth is not native to the United States, however its life cycle does parallel that of a number of other native insects. Gypsy moth larvae feed in spring and early summer on a variety of hardwood foliage. With three repeated defoliations of hardwoods, tree mortality can occur. One defoliation can kill evergreen trees such as pine or cedar.

Looper Complex—although defoliation was light to moderate this group of insects was represented in many counties in 1988. The term, looper complex is used to describe at least five different insects which emerge and feed on a variety of hardwood foliage at the same time of the year. Common loopers are the linden looper, elm spanworm, spring canker-worm, leaf roller and leaf tier. It may take two to three years for looper complex to build to a high level. Predators and parasites usually are responsible for the collapse of large populations of the looper complex.

Trend—population levels should be moderate in 1989.

Suppression—no suppression work was done in 1988.





Scale Insects—as a group infest a variety of hardwood trees throughout the state. These are more common on ornamental hardwood trees such as pin oak, Euonymus, and white and post oak. Some of the scales which were reported during 1988 were the obscure scale on pin oak, Euonymus scale on Euonymus, and Kermes scale on white and post oak. The most devastating scale is the obscure scale which infests pin oak, weakening it and causing decline and mortality.

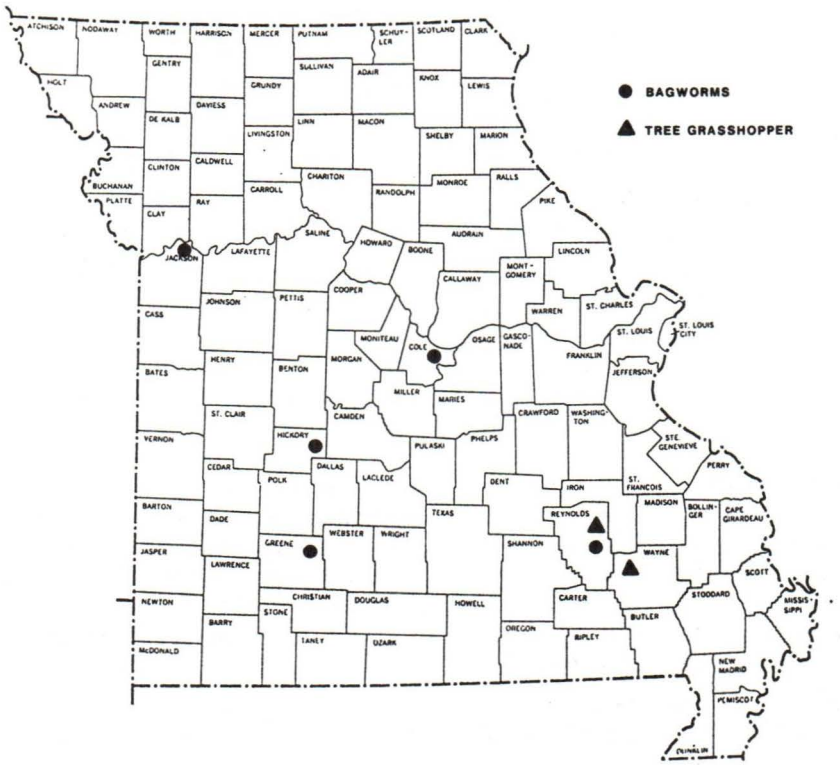
Trend—scales will continue to increase and cause decline on stressed hardwood trees. Scale populations will fluctuate on some tree species depending upon its life cycle.

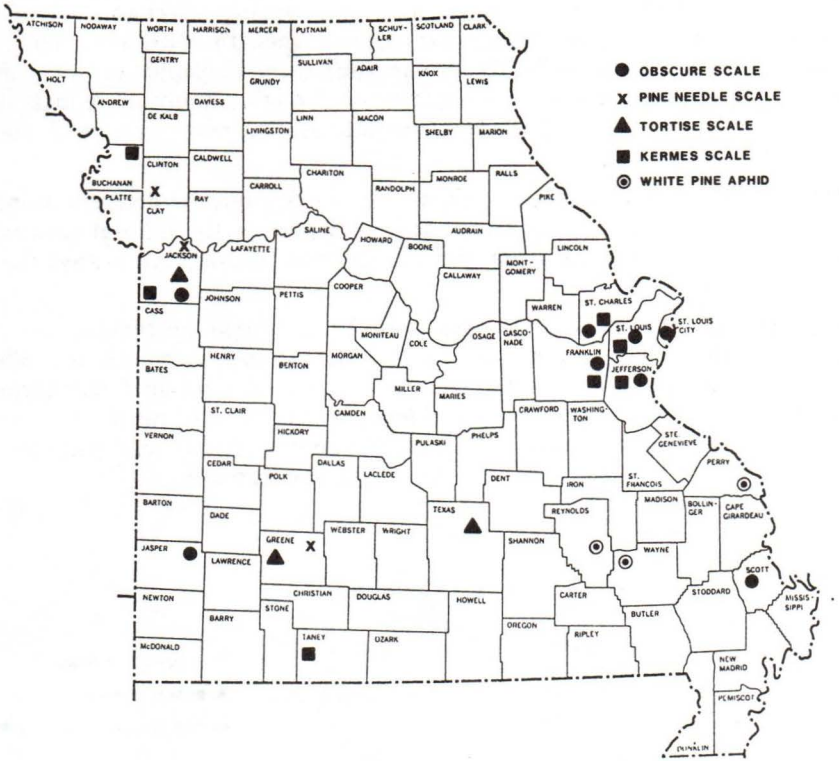
Suppression—arborists use dormant oil and an approved insecticide to control the crawler stage of the scale in spring.

Willow Leaf Beetle—infested black willow natural and planted causing heavy defoliation in 23 counties. Both the larvae and adult are gregarious feeders causing rapid defoliation.

Trend—populations could be high again in 1989 unless parasites or predators intercede.

Suppression—defoliation was noted and reported by fisheries biologists who are doing riparian establishment work using willow posts. Recommendations were made in 1988 to us Safer's Insecticidal Soap to control the leaf beetle in view of the sensitive issue of using any chemical insecticide





Hardwood Borers

The Carpenterworm and Red Oak Borer—and other living tree hardwood borers as part of our endemic, indigenous borer populations continue to infest hardwood trees in our forested and urban areas of the state. Hardwood borers are a major problem on many newly planted and smaller caliper sized hardwood trees in urban areas.

Trend—borer infestation will continue in hardwood trees occupying poor sites. Estimated dollar loss to the hardwood borer complex amount to $2,500,000 annually through lumber degrade and ornamental tree loss.

Suppression—selective tree harvest, sanitation harvest and stand conversion, from hardwood to pine were conducted in forested areas over the state. Some shade tree owners controlled borer infestations on high value trees.

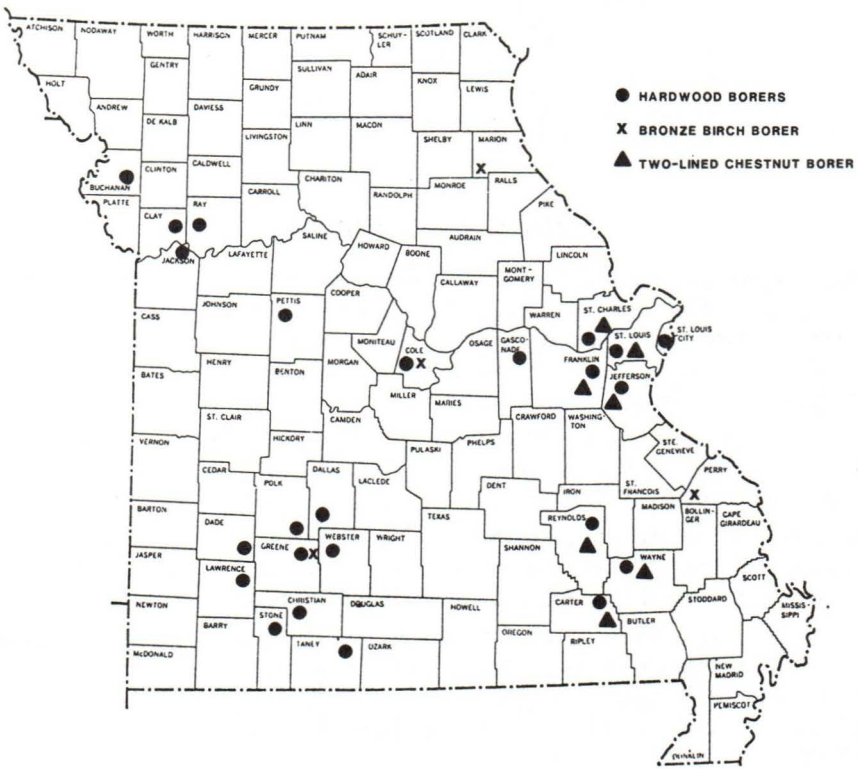
The Cottonwood Twig Borer, Cottonwood Borer, Cottonwood Leaf Beetle and Poplar Tent Maker—continue to infest cottonwood where it grows. Borer damage is greater in trees growing on sites not suited to growing cottonwood. Defoliation by the Poplar Tent Maker occurs also everywhere cottonwood grows.

Trends—no increase in infestation is expected in 1989.

Two-Lined Chestnut Borer—is a secondary attacking insect of stressed oak trees. It plays a role along with various root rots. In 1983, 1984 and 1988 drought conditions prevailed from late June through September over most of the state. As a result of the effects of drought, many more oak trees were lost. Other stressing factors are late frosts, poor sites, and spring defoliating insects.

Trend—mortality will occur again in our forests due to deficient rainfall. Trees are continually dying in the forest as part of the natural succession of a maturing forest. Drought along with other factors will always play a role in tree mortality.

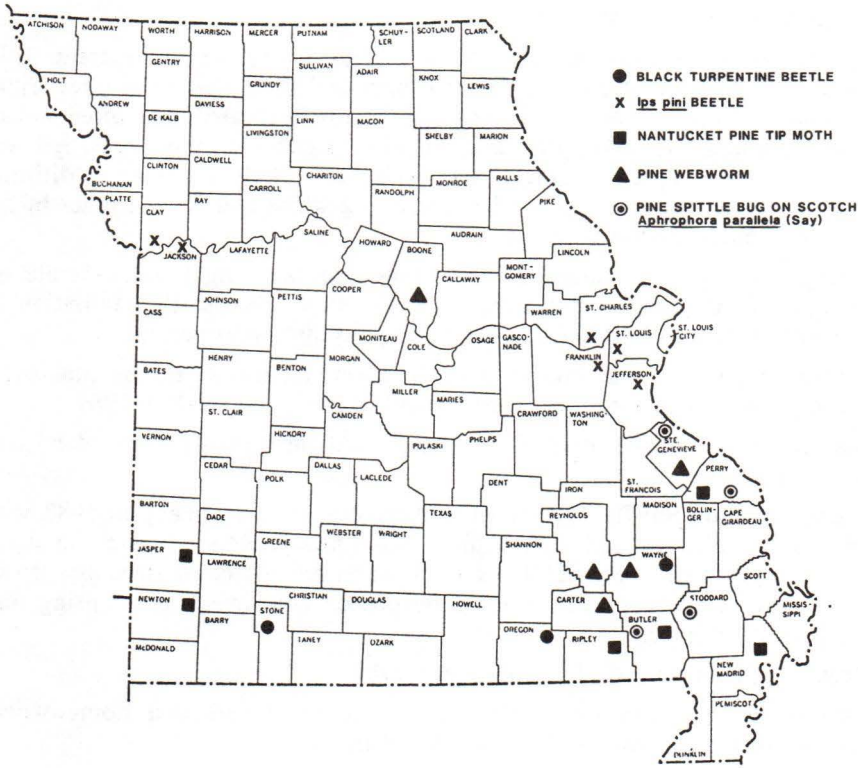
Suppression—drought hazard sites must be identified by the forester and managed in such a manner as to consider species composition. Where hardwood basal area is too low, alternatives such as even-aged management or pine conversion should be considered within the shortleaf pine range. On droughty, poorer hardwood sites the entomological and pathological rotation should be applied rather than a fixed rotation age.



Bronze Birch Borer—populations continue to infest stressed white birch over the state causing extensive mortality. The insect is attracted to white birch wherever it grows.

Trends—stressed white birch will continue to die as a result of the stress factor which is usually drought and from the bronze birch borer infestation.

Suppression—a number of owners spray or have arborists spray their white birch trees. An effort is being made to acquaint nurserymen and landowners with our native river birch as a substitute for white birch.



Pine and Cedar Trunk Borers, Twig Borers and Defoliators

Black Turpentine Beetle—light infestation was reported in Oregon and Wayne counties. The black turpentine beetle infests weakened shortleaf pine trees; those damaged in a timber sale, damaged during building construction, wind thrown or those struck by lightning. Once the infestation has proceeded and is successful, the *Ips* beetle can also develop, complete the process of killing the tree.

Trend—beetle populations will develop where shortleaf pine trees are disturbed either naturally or artifically.

Suppression—where feasible, attacked trees are removed as timber cutting progresses in timber sale areas.

Ips Beetle—is a weak attacker of live healthy shortleaf pine trees. It is most usually detected on very stressed pines and pines that have infestations of black turpentine beetles. If new pine slash is created, *Ips* often infests this slash and will later infest live, healthy neighboring pine trees. *Ips* was reported from seven counties, although very likely pines in additional counties were infested. *Ips* has been infesting white and Scotch pines in the St. Louis and Kansas City areas.

Evergreen Bagworm—infestations of bagworm were light to moderate on upright pfitzer junipers and cedar over the state. Frequently defoliation of infested plants can lead to death over a two- to three-year period.

Trend—bagworms will continue to threaten unsprayed ornamental evergreen. Populations are expected to be light to heavy statewide in 1989.

Suppression—some owners of evergreens had their shrubs sprayed by tree service companies.

European Pine Sawfly—populations were moderate to heavy in 1988 with defoliation of mugo and Scotch pines being heavy. Reports were submitted from 27 counties where defoliation was observed. Affected trees are grown for Christmas tree or ornamental purposes. This insect is a spring and early summer feeder.

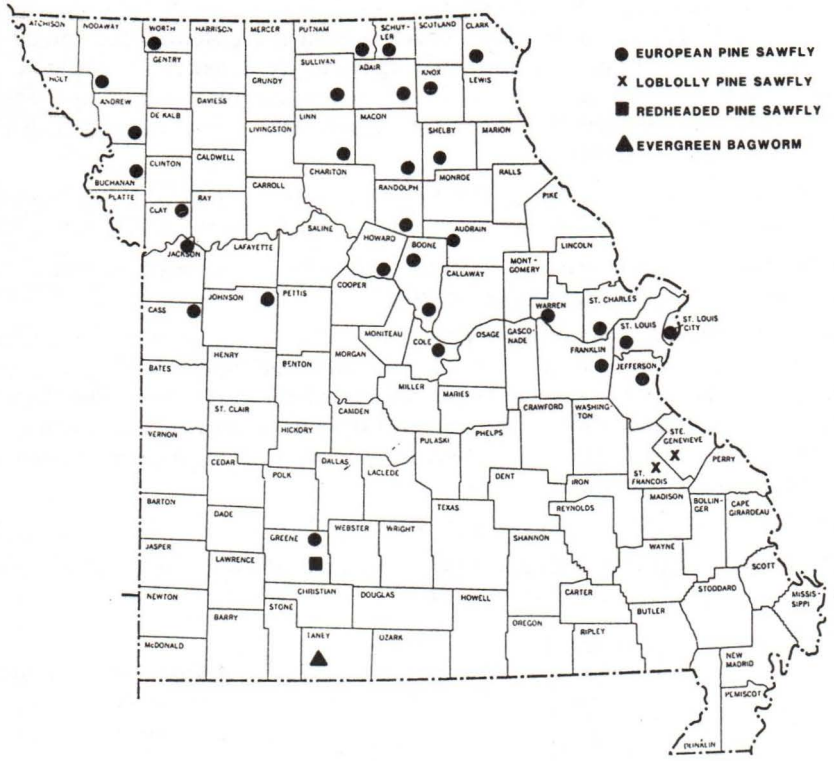
Trend—populations will be moderate in 1989.

Suppression—a number of Christmas tree producers and homeowners sprayed their plants where this insect was a threat.

Loblolly Pine Sawfly—populations were light in 1988. This is an early summer defoliator of shortleaf and Scotch pines.

Trend—populations should be light in 1989.

Suppression—no control was required.



Redheaded Pine Sawfly—populations were light in 1988, being reported from Greene County.

Trend—populations will be light in 1989.

Suppression—no control was conducted in 1988.

Pales Weevil—populations were low in 1988. Infestations were reported for three counties with feeding and flagging occurring on Scotch and white pines.

Trend—populations should be light to moderate in 1989.

Suppression—no suppression was required this year. Our standard control recommendation is to spray stumps produced during the previous Christmas with Thiodan and diesel fuel in March of the following year. Unless growers already have the problem they usually don't take control measures to prevent possible weevil build ups for the following year.

Pine Needle Scale—populations were moderate in scattered areas around the state and specifically in Jackson and Warren counties in 1988. The scale occurs on the needles of Scotch and mugo pines. Scales can build on needles in such large numbers that the plant appears to be whitewashed.

Small infestations should be controlled before the populations grow too large and difficult to control. There is always a potential for spread to surrounding Scotch pine trees. Although the pine needle is difficult to control, superior dormant oil can be used anytime of the year and Sevin or Dursban can be used to control the crawler stage synchronized with the blooming of lilac in spring.

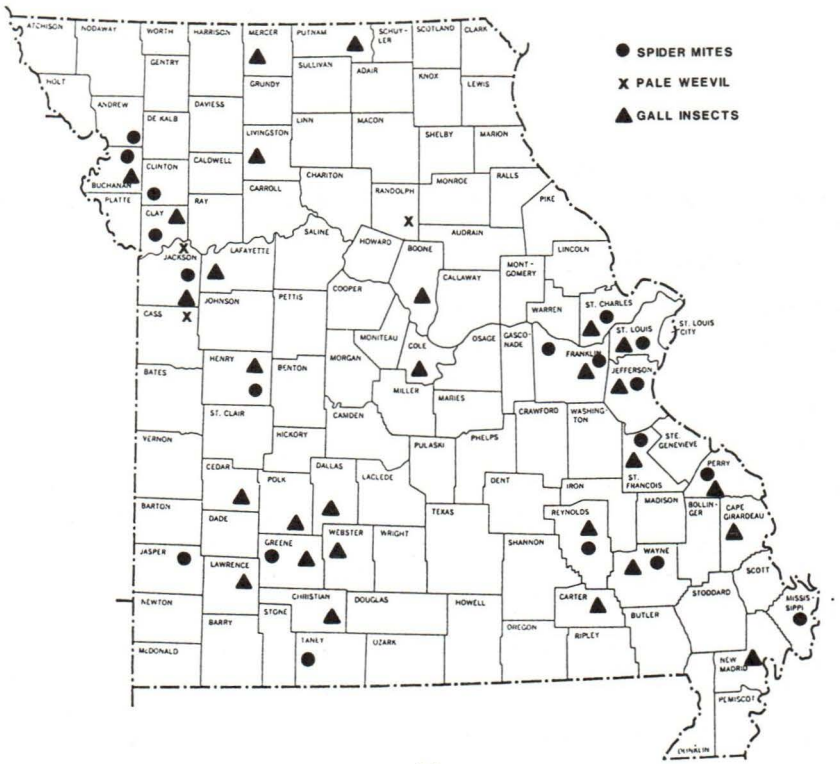
Trend—populations appear to be building slightly. Unless some natural biological control factor intervenes infestation will be on the rise in 1989.

Suppression—several growers sprayed individual and selected trees and shrubs to control pine needle scale in 1988.

Pine Webworm—populations increased in 1988. The pine webworm adult is a moth. The larvae feed on needles of shortleaf and Scotch pines and creates a packed mud-like cluster on the top of the main stem. Defoliation occurs mostly on smaller pine trees which retards growth and causes an unsightly tree. Infestations occurred in Boone, Carter, Ripley, Reynolds and Ste. Genevieve counties in 1988.

Trend—populations will build slightly in 1989.

Suppression—certain Christmas tree producers sprayed their Scotch pine tree with an approved insecticide.



Pine Tortise Scale—infested Scotch pine Christmas trees in plantations in Greene, Jackson and Texas counties in 1988. This insect does not normally become epidemic in a planting because of natural predation by lady beetles and predaceous bugs. Only large trees are usually affected in scattered plantations.

An infestation can be detected by the honeydew which has molded imparting a gray or black cast to the infested portion of the tree.

Trend—populations should be light in 1989.

Suppression—Christmas tree producers were advised to spray dormant oil on only those trees infested prior to winter. If required, growers will spray their infested trees in late May of 1989 with Sevin or Dursban to control the crawler stage of the scale.

Spider Mites—are normally a nuisance on various tree species in summer. Infestation was heavy over the state in 1988. Reports of occurrence were received from our foresters statewide. Spider mites are especially damaging to Scotch pine, baldcypress, Norway spruce, white pine, and Colorado and white spruce. This was an ideal summer for development of spider mites, hot and dry for prolonged periods. Feeding by spider mites produces a light-green, mottled color to the needles. Upon closer examination, egg cases, mites and webbing can be observed on infested plant material.

Trend—if the summer of 1989 is hot and dry, spider mite populations will be high. Although feeding seldom directly kills trees, it does stress them and damages the aesthetic value of Christmas trees as ornamental plants.

Suppression—arborists use miticide to control the various species of spider mites. Christmas tree producers spray their Scotch pine trees for spider mites as the problem develops.

White Pine Aphid—populations were light in three counties in 1988. The aphids suck the sap from small twigs and needles. The honeydew which the aphid produces eventually turns a gray-black. The aphid was reported as occurring in Perry, Reynolds and Wayne counties in 1988.

Trend—populations should be low on white pine in 1989.

Suppression—several owners had their white pine trees sprayed with an approved insecticide to control the aphid.

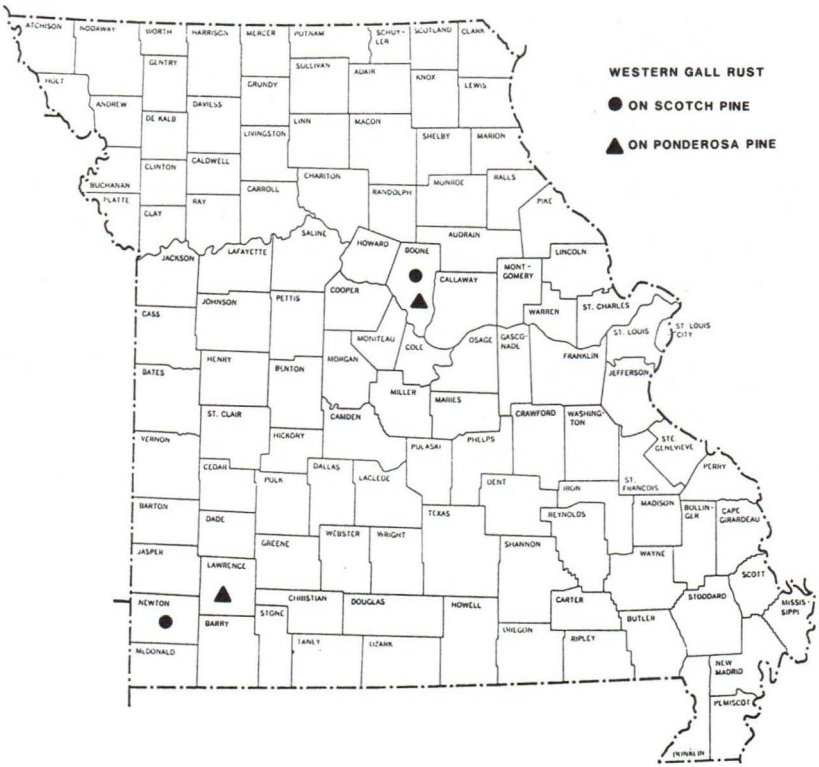
Forest and Shade Tree Diseases

(Conifer Diseases)

Western Gall Rust—was identified for the first time on Scotch pine in Missouri. The infected plantation (a single tree) was found by a Department of Agriculture nursery inspector in a Christmas tree plantation. An aeciospore germination test performed in this laboratory confirmed the diagnosis (see appendix). A second Scotch pine plantation near Diamond in Newton County may also be infected and will be evaluated next spring. Two other locations of the disease are known, both on ponderosa pine and in plantations on University of Missouri experimental farms in Boone and Lawrence counties.

Trend—the infected plantations will be re-inspected next year, although no significant increase in infection is expected.

Suppression—infected trees were eradicated before aeciospore dispersal in the spring.



Diplodia Tip Blight—new shoot tip infections on Austrian pine were at low levels because of dry weather during bud expansion. Damage to older Austrian pines from previous years branch tip infections and cankers on older branches continued. Shoot tip infections, caused by the Diplodia fungus, were found in a number of older Scotch pine Christmas tree plantations.

Trend—the drought has weakened many pines and increased their susceptibility to tip blight and stem infection by the Diplodia fungus. Damage from new shoot tip infections will depend on spring weather conditions during bud expansion.

Suppression—benlate, bordeaux mix or other copper containing fungicides applied at budbreak and again a week later were used for Diplodia tip blight control.

Lophodermium Needlecast—caused minor damage in 1988. This is in direct contrast to 1987 when an outbreak of the disease occurred. In the six counties the disease was identified, disease incidence was low and most trees were less than 10 percent defoliated. Normal to below normal precipitation levels around the state from July to October in 1987 were probably responsible for the low levels of Lophodermium needlecast this year.

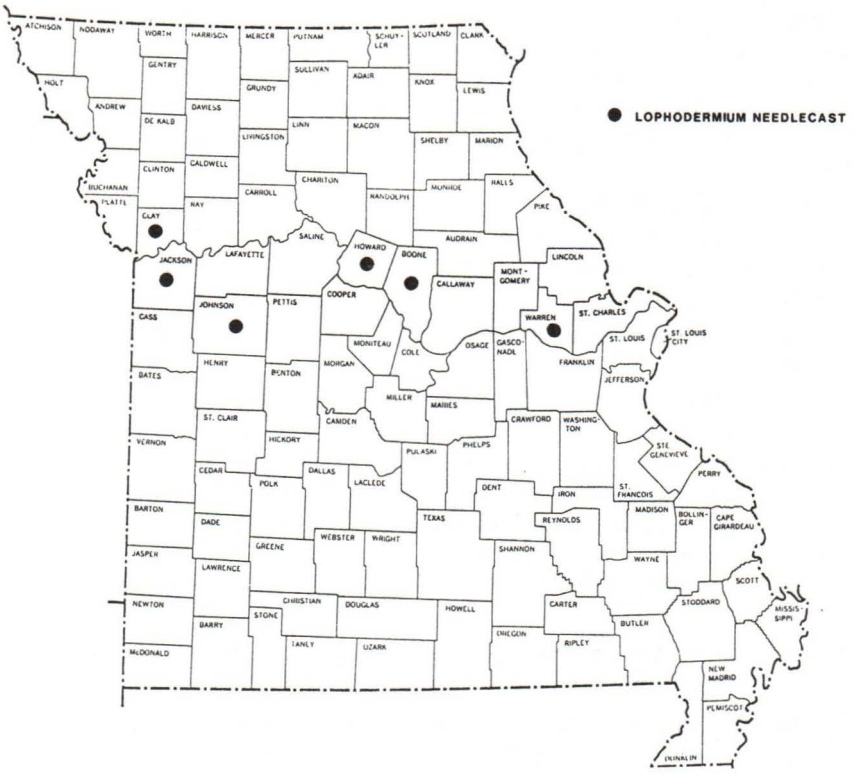
Trend—July to October were dry in most parts of the state. Low levels of Lophoderium infection are expected next spring.

Suppression—good control of Lophodermium needlecast was found this spring by growers that sprayed chlorothalonil starting in late July last year. Most growers also used two additional applications in the period from August to October. Fungicidal control may not be necessary in the future if low infection levels continue.

Pine Wilt Disease—killed a large number of Scotch pine growing in ornamental and windbreak plantings. Austrian pine was affected to a lesser degree and jack pine was the only native pine killed by pine wilt. The disease was also identified in four Christmas tree plantations. The severe drought this year apparently contributed to the development of the disease in the plantations and the increase in other plantings.

Trends—an increase in pine wilt disease is expected again in 1989, because drought stress appears to be associated with an increased susceptibility to pine wilt.

Suppression—removal and destruction of infected pines before the end of March is the only current management practice. Sanitation is aimed at reducing levels of *Monochamus* spp. which vector the pine wood nematode.



Hardwood Diseases

Ash Yellows—caused by mycoplasma-like organisms (MLOs) was confirmed for the first time in Missouri from declining white ash. The MLOs were identified using the DAPI DNA staining technique in root samples sent to Cornell University. Disease incidence and severity was high in most stands with 50–70 percent of the trees exhibiting extensive dieback and decline. Witches' brooms, deliquescent branching, epicormic sprouts, frost cracks, and chlorosis were present on some trees. Thinning of crowns, reduced growth rates, and branch dieback were the most common symptoms.

Trend—the extent of decline on white ash indicates ash yellows has been in Missouri for some time. Drought conditions will accelerate the decline symptoms associated with the disease.

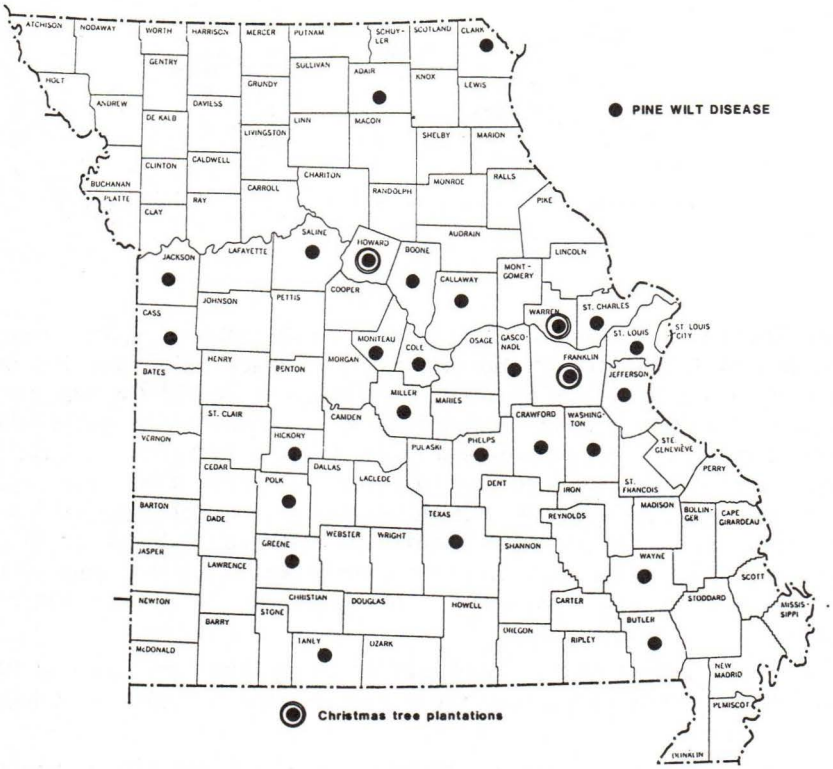
Suppression—no suppression tactics have been initiated.

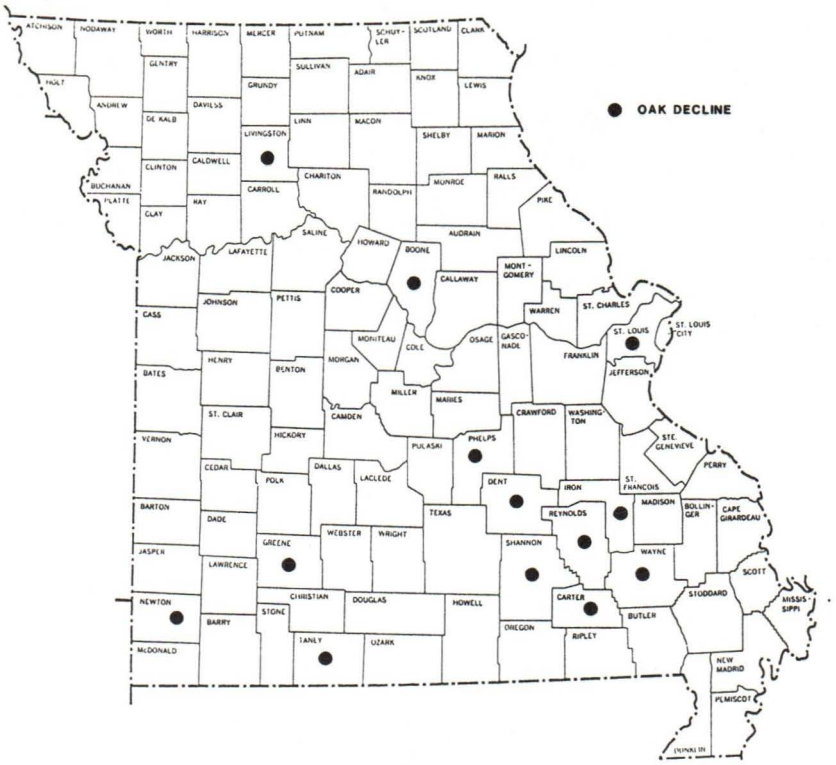
Drought Damage—the extended dry weather and high temperatures of the 1988 growing season adversely impacted both hardwoods and conifer species statewide. Direct tree mortality from the drought was minimal, although

extensive seedling mortality, growth reduction, leaf scorching, premature foliar browning and increased susceptibility to insect and disease problems occurred because of the drought. Palmer Drought Severity Index (PDSI) values are reported below for May through October. The PDSI reflects soil moisture levels in both the upper and lower soil profiles.

Trends—moisture deficits have continued into the fall and soil moisture levels are still well below normal in most areas. Pine wilt disease of Scotch pine, oak decline, and decline problems on other tree species will increase in 1989 because of the extended drought. Conifers may be more prone to winter injury because of low soil moisture levels.

Suppression—watering was recommended where feasible in ornamental situations. Timber salvage in oak decline areas was carried out on severely affected stands.

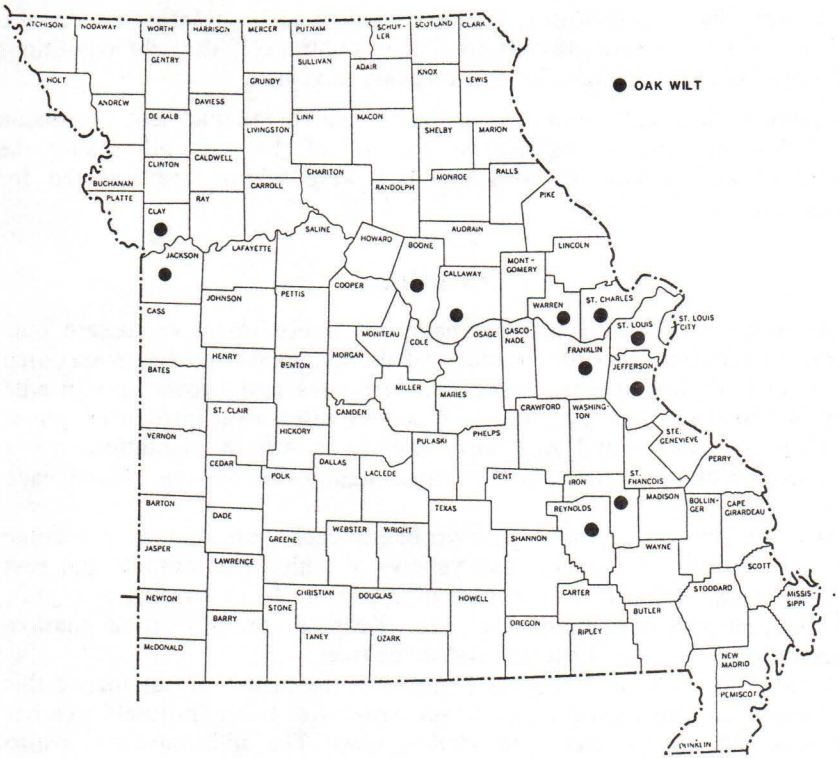




Oak Decline—continued to affect a large number of oaks, particularly in the eastern Ozark Region. Scarlet, red, and black oaks were the most severely affected species. Drought conditions increased the amount of decline, although a dramatic increase in the disease was not evident. Secondary agents such as two-lined chestnut borer, Armillaria root rot and Hypoxylon canker, were common on declining trees. Trees that rapidly "scorched" or browned out later in the growing season were evident at moderate levels but generally showed no evidence of insect or disease agents. In urban areas, oak decline was observed on a wider range of oak species and was usually associated with site or root disturbance, soil compaction or mechanical injury.

Trend—oak decline will continue to affect a large number of oaks in 1989. Oak decline tends to increase for a number of years after a period of severe drought.

Suppression—salvage timber cuts were made in areas with severe oak decline. Stands with moderate decline were left undisturbed because thinning or other activities tend to increase the severity of the decline.



Oak Wilt—most damage from oak wilt was in urban areas on large, mature shade trees. Pin, red, shingle and black oak were the most commonly affected species. In forest situations, oak wilt was at endemic levels and did not cause significant loss of timber.

Trend—oak wilt is expected to continue at endemic levels in 1989.

Suppression—severing root grafts, removing affected trees and avoiding wounding oaks in the spring and early summer were recommended for oak wilt.

Sycamore Anthracnose—was severe on many American sycamores this year. Although weather conditions were generally dry in early spring, cool weather during bud expansion was favorable for disease development. Many trees failed to leaf out fully because of canker and shoot blight phase of the disease. Drought conditions in the spring slowed or inhibited refoliation of anthracnose-infected trees. The anthracnose-drought combination also caused branch dieback and decline on some trees.

Trend—severity of anthracnose is closely tied to spring weather conditions. Decline on anthracnose infected trees may continue if drought conditions or a severe anthracnose infection occurs again next year.

Suppression—fungicide applications during bud break and leaf expansion or injection of certain fungicides in the fall of the year will reduce the severity of anthracnose. Control practices were seldom implemented for anthracnose.

Conclusions

Although we do not currently have any major insect or disease outbreaks, we continue to suffer insect and disease losses in certain resource groups. Oak decline in the Ozarks, spider mites and brown spot needle blight in Christmas tree plantations, pine wilt disease on introduced pines, and Fusarium canker and *Acrobasis* damage in walnut plantations are a few examples of pest problems that cause significant monetary losses each year.

We are also finding new pest problems each year that may become more important in the future. Ash yellows of white ash, western gall rust of Scotch pine, and yearly trappings of gypsy moth, all evident this year, show our pest problems change each year. Keeping abreast of these changes is essential to protecting our forest and shade trees.

Drought conditions that greatly impacted the health of our forests this year, continued into the fall. Significant departures from "normal" weather conditions will always stress and weaken trees. The additional stress also means increased pest problems and losses.

As always, we have been able to collect and assemble this statewide pest incidence information because of our District reports. Cooperation and team effort has always been a key to a successful Forest Pest Management Program.

Insect-Host	County
Bagworm *Thyridopteryx ephemeraeformis* (Haw.) on assorted evergreens and certain hardwoods	Statewide
Black Turpentine Beetle *Dendroctonus terebrans* (Oliv.)	Oregon, Wayne
Borers Hardwood	Buchanan, Carter, Clay, Christian, Cole, Dade, Dallas, Franklin, Gasconade, Greene, Jackson, Jefferson, Lawrence, Pettis, Polk, Ray, Reynolds, Stone, St. Charles, St. Louis, St. Louis County, Taney, Wayne, Webster
Bronze Birch Borer *Agrilus anxius* (Gory)	Statewide
Calosoma Beetle *Calosoma scrutator* (Fabricius)	Wayne
Cottonwood Borer *Plectrodera scalator* (F.)	
Cottonwood Leaf Beetle *Chrysomela scripta* (F.)	
Cottonwood Twig Borer *Gypsonomia haimbachiana* (Kft.)	
Two-lined Chestnut Borer *Agrilus bilineatus* (Web.)	Statewide
Twig girdler *oncideres cingulata* (Say) Hickory and persimmon	Cole, Iron, Reynolds
Eastern Tent Caterpillar *Malacosoma americanum*(F.) on Prunus sp.	Statewide
Elm Leaf Beetle *Pyrrhatta luteola* (Mueller) on elm	Statewide
European Pine Sawfly *Neodiprion sertifer* (Geoff.) Scotch and mugo pines	Adair, Andrew, Boone, Buchanan Cass, Clark, Clay Cole, Franklin, Greene, Howard, Jackson, Johnson, Knox, Linn, Macon, Nodaway, Putnam, Randolph, Shelby, St. Charles, St. Louis, St. Louis Co., Sullivan, Warren

Fall Webworm *Hyphantria cunea* black walnut and other hardwood species	Statewide
Gall Insects on assorted Hardwoods	Statewide
Gypsy Moth (in traps)	St. Louis, Texas, Jackson, Webster
Hackberry Butterfly *Astercampa clyton* B.&L. on hackberry	Phelps
Ips pini on pines	Clay, Franklin, Jackson, Jefferson, St. Charles, St. Louis, St. Louis City
Imperial Moth *Eacles imperilis*	Cole
Kermes Scale *Kermes pubescens* (Bogue) on white and post oak	Buchanan, Franklin, Jackson, Jefferson, St. Charles, St. Louis, Taney
Loblolly Pine Sawfly *Neodiprion taedae linearis* (Ross) on shortleaf pine	St. Francois, St. Genevieve
Looper Complex on hardwoods	Statewide
Nantucket Pine Tip Moth *Rhyaiconia frustrana* (Comst.) on shortleaf pine	Butler, Newton, Jasper, Ripley, Perry
Obscure Scale *Melanaspis obscura* (Comst.) pin oak	Jackson, Jasper, Scott, Jefferson, Franklin, St. Charles, St. Louis, St. Louis City
Pales Weevil *Hylobius pales* (Hbst.) on Scotch and white pines	Cass, Howard, Jackson
Pine Needle Scale *Phenacaspis pinifoliae* (Fitch) on Scotch pine	Jackson, Warren,
Pine Tortis Scale *Toumeyella numismatica* (P. & McD.)	Greene, Jackson, Texas
Pine Webworm *Tetralopha robustella* (Zeller) on Scotch an shortleaf pines	Carter, Reynolds, Wayne, Ste. Genevieve
Poplar Tent Maker *Ichthyura inclusa* (Haldeman)	
Redheaded Pine Sawfly *Neodiprion lecontei* (Fitch) on shortleaf and Scotch pines	Greene
Spider Mites *Oligonychus spp.* and *Tetranychus* spp.	Statewide
Spittlebug, Pine *Aphrophora parallela* (Say) on Scotch pine	Ripley, Perry, Ste. Genevieve, Stoddard

True Tree Grasshopper *Dendrotettix quercus* (Packard) on hardwoods	Reynolds, Wayne
Walking Stick *Diapheromera femorata*(Say) on oak leaves	Cole
Walnut Caterpillar *Datana integerrima* (G.&P.) on walnut, pecan and hickory	Cole
White Pine Aphid *Cinara strobi* (Fitch)	Perry, Reynolds Wayne
Willow Leaf Beetle *Chrysomela interrupta* (F.) on willow	Bollinger, Butler, Cape Girardeau, Carter, Cole Franklin, Gasconade, Jefferson, Madison, Maries, Marion, Osage, Perry, Phelps, Scott, Sullivan, St. Francois, Ste. Genevieve, St. Louis, Stoddard, Texas, Washington, Wayne
Wooly Alder Aphid *Paraprociphilus tesselatus* on common alder *(Alnus serrulata* (Ait)	Iron Reynolds
Zimmerman Pine Moth *Dioryctria zimmermanni* (Grote) on Austrian and Scotch pines	Jackson Newton

Pest and Host	County
Actinopelte Leaf Spot *Actinopelte dryina* (Sacc.) Hoehn. (Pin Oak)	Greene, St. Louis, Cole
Air Pollution (White pine) ozone	St. Louis, Cole St. Francois, Ralls Marion
Annosus Root Rot *Heterobasidion annosum* (Fr.) Bref. (shortleaf pine)	Wayne, Carter, Reynolds
Apple Scab *Venturia inequalis* (Cke.) Wint. (Crab apple)	Cole, Boone, St. Louis, St. Charles, Jackson
Armillaria Root Rot *Armillaria mellea* (Vahl. ex. Fr.) Karts. (Maple, Ash, Red oak, Scarlet oak, Black oak, Hickory, Arborvitae)	Jackson Ripley, Perry, Wayne, Carter, Reynolds, Taney, Stone, Cole
Ash Anthracnose *Gloeosporium aridum* Ell. & Holw. (White and Green ash)	Stoddard St. Francois, St. Louis, St. Charles, Franklin, Jefferson
Ash Yellows Mycoplasmal (White Ash)	Andrew, Buchanan, Franklin, St. Louis, Livingston
Bleeding Necrosis *Botryosphaeria ribis* Gross. & Dug. (Sweet Gum)	Greene, Jackson, Perry
Botryosphaeria canker *Botryosphaeria stevensii* Shoe. (Rocky Mountain Juniper)	Jackson
Brown Spot Needle Blight *Scirrhia acicola* (Dearn) Siggers (Scotch pine)	Buchanan, Boone, Jackson, Newton, Jasper, Taney, Greene, Phelps, Henry, Dallas, Cole, St. Louis,
Cedar Apple, Quince Rust *Gymnosporangium spp.* (Red Cedar, Hawthorn, Crabapple)	Statewide
Cercospora Blight *Cercospora sequoiae* var. *juniperi* Ell. & Ev. (Red Cedar)	Perry, Cole, Moniteau, Boone

Cyclaneusma Needlecast *Cyclaneusma minus* (Butin) Dicosmo, Peredot & Minter (Scotch Pine)	Jackson, Polk, Callaway, Boone, Howard, Wayne, Buchanan, Franklin, Madison
Cytospora Canker *Cytospora Kunzei* Sacc. (Spruce)	Mississippi, Cole, St. Louis, Marion, DeKalb
Diplodia Tip Blight *Sphaeropsis sapinea* (Fr.) Syke & Sutton (Scotch and Austrian pines)	Boone, Jackson, Cole, Clay, Lafayette, St. Louis, St. Charles, Franklin, Jefferson, Andrew, Clinton
Dothistroma Needle Blight *Dothistroma pini* Hul. (Austrian pine)	Madison Howard, Cole, Greene, Livingston, Boone, Andrew, Platte, Newton, Jasper, Johnson
Drought Damage Hardwood and Conifer species	Statewide
Dutch Elm Disease *Ceratoycstis ulmi* (Boism.) Moreau (American elm)	Putnam, Sullivan, Adair, Knox, Clinton, Livingston, Clay, Jackson, Boone, Cass, Pettis, Cooper, Cole, St. Charles, St. Louis, Franklin, Jefferson, Cedar, Greene, Carter, Wayne, Butler
Eastern Gall Rust *Cronartium quercum* (Berk.) Miyabe ex. Shirai f.sp. *echinatae* (Shortleaf pine)	Washington, Newton, Cole, Texas, Butler, Wayne, Carter

Elm Anthracnose *Gnomonia ulmea* (schw.) Thum. (American elm)	Cole, Jackson,
Elm Phleom Necrosis Mycoplasmal (American elm)	Jackson, Cass, Greene, St. Louis
Fire Blight *Erwinia amylovora* (Burr.) Winsl. (pear, apple)	Cole, St. Louis, Greene, McDonald Douglas, St. Francois, Ripley, Butler, Texas, Polk, Andrew
Frost Damage (Various Hardwood Species)	Barton, Jasper, Barry, Lawrence, Newton, McDonald, Wayne Carter, Franklin, Maries, Phelps, Texas, Reynolds, Iron, St. Louis, St. Charles, Jefferson, Franklin
Fusarium Canker *Fusarium solani* (Mart.) Appel & Wollenw. Emend Synd. & Hans. (Black Walnut)	Adair, Scott, Stoddard, Bollinger, Texas
Hypoxylon Canker *Hypoxylon atropunctatum* (Schw. ex. Fr.) Cke. (Black post, red, shingle, scarlet, white and pin oaks)	Jackson, Iron, St. Louis, Jefferson St. Charles, Franklin, Ripley, Reynolds, Lincoln, Wayne, Carter, Clay, Marion, Jasper
Kabatina Tip Blight *Kabatina juniperi* Schn. & V. Arx. *Juniperus spp.*	Jackson, Bollinger, Cole
Lophodermium Needlecast *Lophodermium seditiosum,* Staley & Millar (Scotch Pine)	Jasper, Johnson, Clay, Howard, Boone, Warren

Maple Anthracnose *Gloeosporium apocryptum* Ell. & Ev. (Sugar Maple)	Cedar, Polk, Dade, Greene, Webster, Christian, Stone, Taney, Douglas, Vernon, Buchanan, Jackson, Dent
Maple Decline Complex of biotic and abiotic factors (Sugar, Silver & Red maples)	Reynolds, Jackson, Greene, Marion, St. Louis city
Mycosphaerella Leaf Spot *Mycosphaerella juglandis* Kess. (Black Walnut)	Cole, Texas Howard
Oak decline Complex of biotic and abiotic factors (Post, scarlet oak, red, black Scarlet, shingle, pin, and white oaks)	Taney, Phelps, Wayne, Carter, Boone, Reynolds, Greene, Dent Livingston, Iron, St. Louis, Newton, Gasconade
Oak Wilt *Ceratocystis fagacearum* (Bretz) Hunt (Pin, shingle, red and black oaks)	Jackson St. Louis Boone Callaway Clay, Warren, Jefferson, St. Charles, Iron, Reynolds
Phomopsis Blight *Phomopsis juniperovora* Hahn. (Eastern Redcedar)	Jackson, Bollinger, Reynolds, Newton, Benton, Iron, St. Charles, Jefferson, Franklin, Greene

Pine Needle Rust *Coleosporium asterum* (Diet.) Syd. (Shortleaf and loblolly pines)	Christian, Greene, Wayne, Carter
Pine Wilt Disease *Bursaphalenchus xylophilus* Steiner & Burher (Scotch, Austrian and Jack pines)	Butler, Jackson, Taney, Cass, Greene, Franklin, Hickory, Gasconade, Washington, Crawford, Jefferson, Clark, Boone, Howard, Cole, Wayne, Polk, Saline, Callaway, St. Louis, St. Charles, Adair, Phelps, Miller, Texas, Moniteau, Hickory, Marion,
Ploioderma Needlecast *Ploioderma lethale* (Shortleaf pine)	Wayne
Rhizosphaera Needlecast *Rhizosphaera kalkhoffi* Bub. (Blue spruce)	Greene, Newton Jasper, Jackson, Cole, Phelps, Christian Warren, Lincoln, Adair
Sapsucker Damage *Sphyrapics varius* (Sweet Gum and other hardwood species)	Jackson, Adair, Hickory, Cole
Slim Flux *Erwinia spp.* (Black oak, elm.)	Taney, Cole, Ripley
Sycamore Anthracnose *Gnomonia plantani* Kleb. (Sycamore)	Statewide

Verticillium wilt *Verticillium dehliae* Leb. (Sugar Maple)	St. Louis, Boone, Greene, Pettis, Jackson,
Walnut Anthracnose *Gnomonia leptostyla* (Fr.) Ces. & Den. (Black Walnut)	Cole, Boone, Texas, Buchanan, Clinton, Andrew, DeKalb, Cedar, Polk, Greene, Christian, Webster
Western Gall Rust *Endocronartium harknessi* (Moore) Y. Hiratsuka (Scotch and Austrian pines)	Boone, Newton, Lawrence

Results Administrative Studies

Pine Wilt Disease Survey

A survey of older (15 year and greater) Scotch pine plantations and windbreaks was made in March and April. The purpose of the survey was to evaluate infection levels from the 1987 growing season and to establish base levels of infection for future years' surveys. Trees were scored as healthy, infected by pine wilt in 1987 and showing symptoms but not yet dead (Infected 1987), killed by pine wilt infection in 1987 (Dead 1987) or dead from previous years (Dead). Results from the survey are presented in table 1.

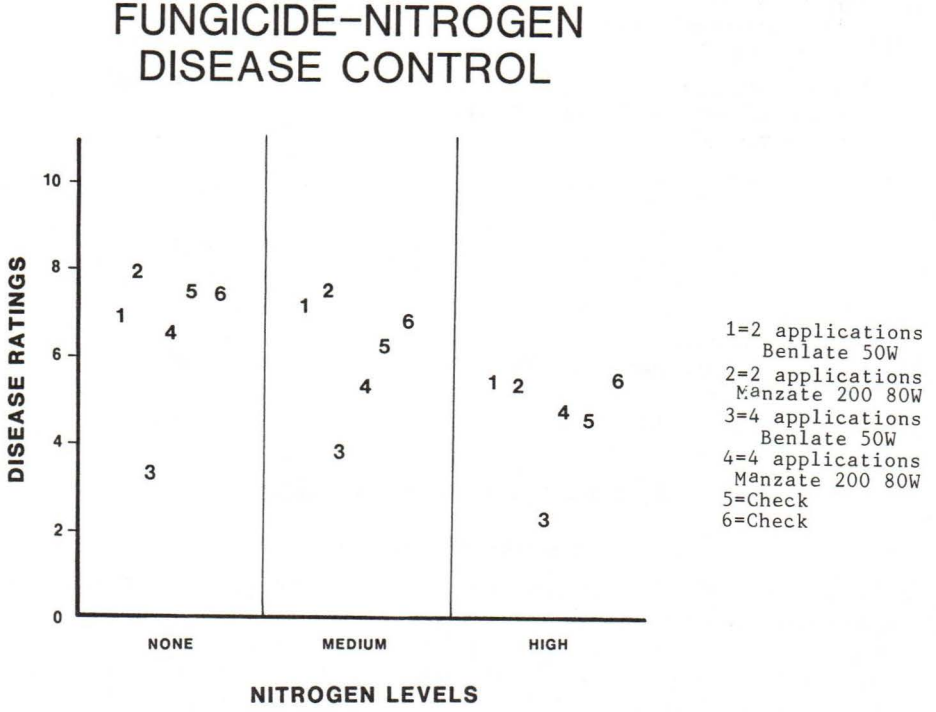
The plantations and windbreaks will be re-evaluated next year.

Evaluation of Nitrogen and Fungicides for Control of Foliar Diseases of Black Walnut

Nitrogen and fungicides were evaluated for control of foliar diseases of black walnut seedlings at the George O. White State Forest Nursery. A split-plot experimental design with four replications, and each with three levels of nitrogen as whole plots and six fungicide treatments as split plots was used.

Ammonium nitrate (33–0–0) was applied on 5 May at the rates of 264 lbs Nai/acre, 99 lbs Nai/acre or 0 lbs Nai/acre. Nitrogen treatments were applied to 7 nursery-bed wide plots that were 310′ long. Application was made before the walnuts had germinated.

Fungicide treatments were benlate 50 W at 1 lb/acre and manzate 80W at 2 lb/acre. The fungicides were applied to 100′ long plots on 26



May, 16 June, or four times on 26 May, 16 June, 14 July and 11 August. There were two untreated check plots.

The nitrogen-fungicide treatment combinations were evaluated on 9 August and 15 September for both anthracnose and Mycosphaerella leaf spot. A 0-5 rating scale was used where 0=no infection, 1=1-10 percent of leaflets infected, 2=11-25 percent, 3=26-50 percent, 4=51-80 percent, and 5=81-100 percent. Each disease was rated separately and the two ratings were combined.

Results are given in figure 1. Statistical analysis showed there was a significant difference in foliar disease ratings among nitrogen levels and fungicide treatments. Four applications of benlate was the best fungicide treatment, while the high level of nitrogen significantly reduced the severity of both foliar diseases in comparison to the other nitrogen treatments.

Growth parameters, root starch reserves and survival in the field of seedling from each treatment will be evaluated this fall and next spring.

Evaluation of *Fusarium Solani* as a Pathogen of Black Walnut

Three isolates of *Fusarium solani* were evaluated for pathogencity on seedlings of black walnut. Two of the isolates were from cankers on black walnut growing in a Texas county plantation and the third isolate was from Kansas (isolated from black walnut by Ned Tisserat, Kansas State University). The seedling were grown and inoculated in a greenhouse at the George O. White Forest Nursery. Inoculations were made either by placing a piece of agar with mycelia and spores of *F. solani* in a 1 cm slit made near the shoot tip (slit inoculations) or introducing a mycelial-spore suspension into the shoot on a probe poked into the stem (poke inoculations). Three seedlings in each of four replications were inoculated for each isolate-inoculation type combination. Sterile inoculations (checks) and inoculations were evaluated and reisolated from 45 days after treatment.

All slit inoculations caused considerable discoloration around the inoculation site, and tip dieback. *F. solani* was reisolated from 77 percent of the seedlings. Poke inoculations were less successful; 52.7 percent of the inoculation caused discoloration and tip dieback. The remaining poke inoculations caused limited discoloration around the inoculation site or were callused over, although *F. solani* was reisolated from 94 percent of the inoculations. There was no observable difference in symptoms caused by the isolates. Check inoculation were negative for both symptoms and isolation of *F. solani.*

Confirmation of Western Gall Rust on Scotch Pine

Multiple branch galls were observed on Scotch pine in a Christmas tree plantation near Columbia by Frank Rycyk, Jr. of the Missouri Dept. of Agriculture. This study was initiated to determine if the disease was western gall rust (pine-pine rust), which was previously only known from two ponderosa pine plantations in the state. The infected Scotch pine was moved to a ponderosa pine plantation on University of Missouri property (South Farms, Columbia, MO). Western gall rust had been previously identified in the plantation.

On 19 May sporulating galls were collected from the Scotch and ponderosa pines. Aeciospores of *E. harknessi* were then germinated on 2 percent water agar at 18.5°C for 24 hours. The water agar plates were preconditioned at 18.5°C for 1 hour before aeciospores were brushed on the agar surface with a sterile #6 camel hair brush. The germinating spores were killed and stained with lactophenol in cotton blue and 50 spores in each of four replications were evaluated for germ tube length, lysis of germ tubes and branching characteristics.

No lysed germ tubes were observed. Germ tubes from the pine sources had a similar frequency with branches (21.5 percent Scotch pine source and 25 percent ponderosa pine source). Less than 0.75 percent of both

sources had germ tubes with more than one branch, and 95 percent of the germ tube branches for both sources were in the proximal 50 percent of the germ tube. Germ tube lengths are reported in the table below.

Results for all germ tube characteristics are not significantly different than those reported for *E. harknessii* from other locations.

Germ Tube Lengths in Microns After Incubation of Aeciospores for 24 Hours at 18.5C

Source	Replication 1	2	3	4	Average	SD
Scotch pine	283.1	270.4	218.8	215.6	246.91[1]	34.7
Ponderosa pine	264.4	267.7	205.5	235.4	243.21[1]	29.1

[1]Not significantly different at P=0.05

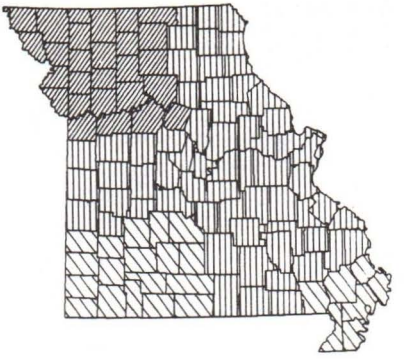
TABLE 1

Planting	Percent Healthy	Percent Infected 1987	Percent Dead 1987	Percent Dead	Total Trees
Short Plantation—South Cole County (S32,T41N,R13W) 23-year-old abandon Christmas tree plantation	79.9	1.8	7.6	10.7	497
Short Plantation—North Cole County (S32,T41N,R13W) 23-year-old abandon Christmas tree plantation	80.5	0.3	7.9	11.2	616
Rademan Plantation Cole County (S33,T45N,R13W) 28-year-old abandon Christmas tree plantation	57.8	3.0	10.2	28.9	166
C-Highway Windbreak Moniteau County (S24,T43N,R15W)	91.2	1.8	6.3	0.6	159
I-435 Windbreak Jackson County (S31,T48N,R33W)	97.2	0.4	0.7	1.3	609
Average	81.3	1.5	6.5	10.5	409.4

May 1988

Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

June 1988

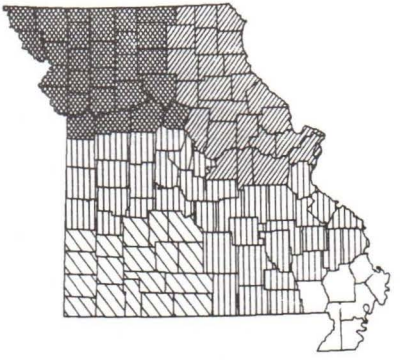


Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

July 1988

Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

August 1988



Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

September 1988

Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

October 1988

Extreme Drought
Severe Drought
Moderate Drought
Mild Drought
Near Normal or Moist

Forest Pest Management
Missouri Department of Conservation
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Jefferson City, MO 65102

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